A Star Tech, The Final Front-MIR: Estimated breeding values for mid-infrared derived predictions of energy traits in dairy cows.

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Speaker: Steph Smith

A STAR TECH:

THE FINAL FRONT-MIR

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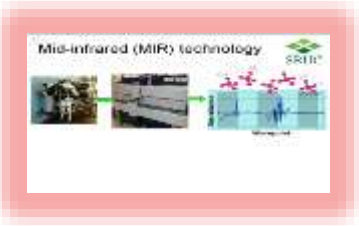
Scene Selection



Scene 1

Introducing MIR

Scene 2

The importance of phenotypes

Scene 3

Developing prediction tools for energy traits

Scene 4

Developing prediction tools for the incidence of ketosis

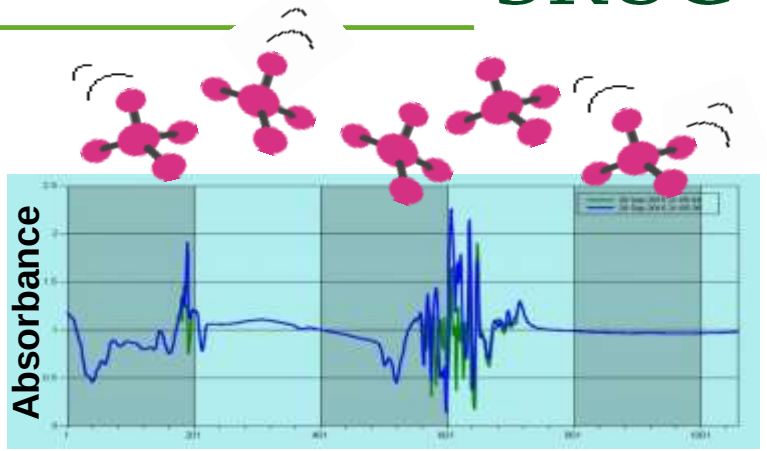
Scene 5

Tool application

Scene 6

Conclusions & thanks

Scene 1: mid-infrared technology



National Milk Laboratories tour: Friday 16th

Fat %

Protein %

Fatty acids

Soyeurt et al. (2011)

Energy balance

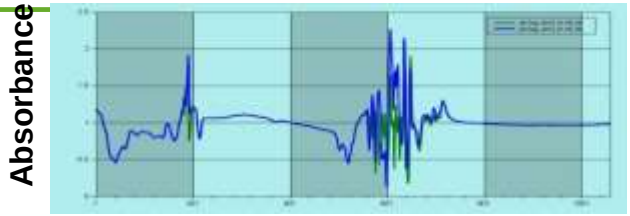
McParland et al. (2011)

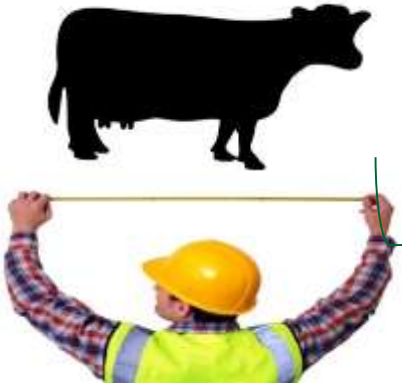
Objective : Can we detect other physiological or biochemical signatures from milk MIR spectra?

Scene 1: mid-infrared technology

Research animal measurements

MIR spectral data





Alignment & calibration

Statistical analysis

Other milk production data

Predicted trait

Internal cross – validation

Initially developed by McParland et al. 2011

“In the age of the genotype…..

PHENOTYPE IS KING!”

- Mike Coffey

#INTHEAGEOFTHEGENOTYPEPHENOTYPEISKING

SRUC Dairy Research herd

The data

- ✓ 922 Holstein – Friesian dairy cows
- ✓ 2003 – 2014
- ✓ 5 lactations
- ✓ c.520,000 records

Cows subject to long term 2 x 2 factorial exp.

	Genetic	
Diet	S HF	C HF
	S LF	C LF

Phenotypes recorded:

- ✓ Milk yield
- ✓ Fat %, protein %
- ✓ Live weight
- ✓ Body condition score
- ✓ Dry matter intake

Diet components :

- ✓ Organic matter digestibility (% DM)
- ✓ Metabolizable energy (MJ/kg DM)
- ✓ Crude protein (g/kg DM)
- ✓ Organic matter (g/kg DM)

Blood sample analyses ;

- ✓BHB
- ✓NEFA
- ✓Urea
- ✓Lactoferrin

SRUC Dairy Research herd

Modelling

Fixed effects

- ✓ Genetic group
- ✓ Feed group
- ✓ Calving age (months)
- ✓ Year of calving by season of calving interaction
- ✓ Year of record by month of record interaction
- ✓ Year of record by experimental farm interaction
- ✓ Days in milk (poly 4)

Smoothed dairy phenotypic records for each cow/lactation/days-in-milk

Random effects

- ✓ Days in milk (poly 4) by animal interaction

Use to calculate body energy traits:

- ✓ Daily energy balance (EB, megajoules/day)
- ✓ Daily energy intake (EI, megajoules/day)

Energy balance (MJ/d)

Calculated based on milk yield, fat and protein content, dry matter intake, body weight, body condition score

Equations developed by Emmans (1994); Banos and Coffey (2010)

EB = Energy in − Energy out

Feed

Maintenance, lactation, methane

For example a score of 55 means that the cow is in positive energy balance by an excess of 55MJ, at the time measured

Effective energy intake (MJ)

Calculated based on organic matter intake, digestible crude protein, metabolisable content.

Equations developed by Emmans (1994); Banos and Coffey (2010)

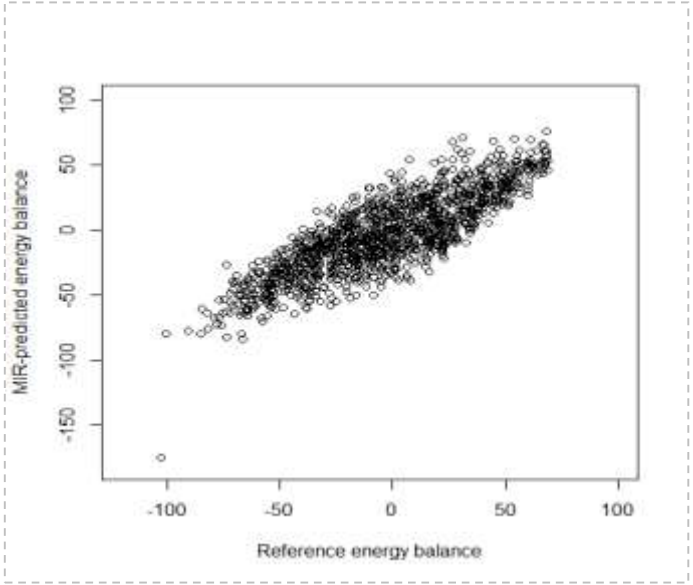
EI = Energy in — Energy used to digest

Feed

For example a score of 230 means that a cow has consumed 230 MJ of food, once it has been processed, at the time measured

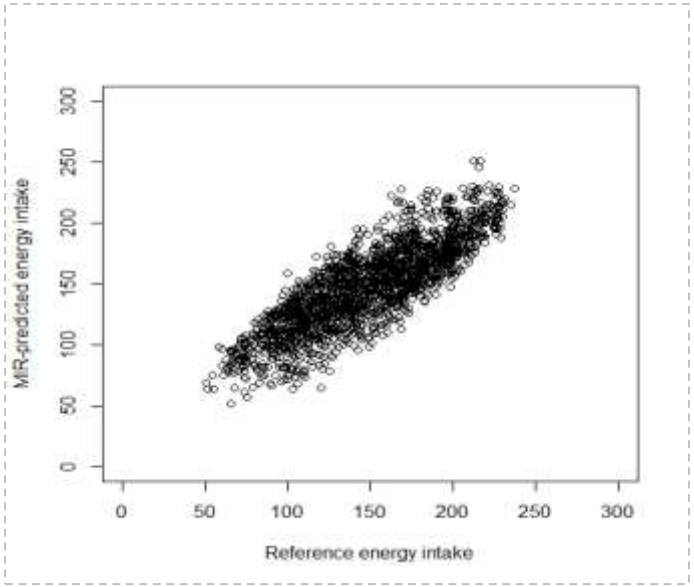
Scene 3: MIR-derived energy prediction tools

Energy balance



R = 0.84
SEC = 22.7
SDEP = 19
RPD = 1.6

Energy intake



R = 0.84
SEC = 24.2
SDEP = 21.7
RPD = 1.6

Scene 4: MIR-derived ketosis prediction tools

Ketosis is a metabolic disorder in which the body has to derive energy from ketone bodies

BHB = B-hydroxybutyrate and is a very stable 'ketone body'

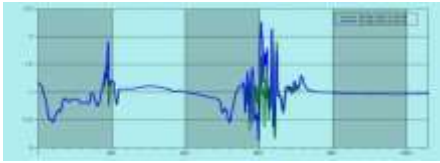
NEFA = Non-esterified fatty acids and a measure of fat mobilisation

BHB mmol/l

Sub clinical ketosis

Healthy

Clinical ketosis



Partial Least Squares Analysis

NEFA mmol/l

Excessive fat mobilisation

Healthy

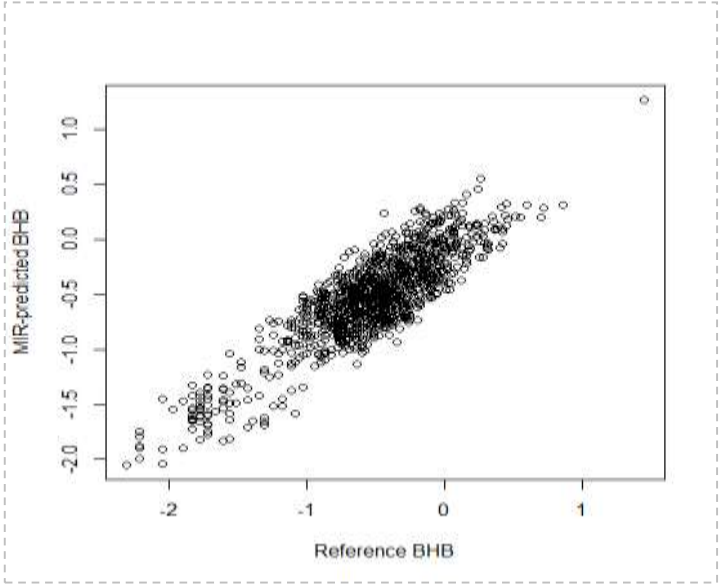
Severe mobilisation

Predicted *NEFA*

Validation

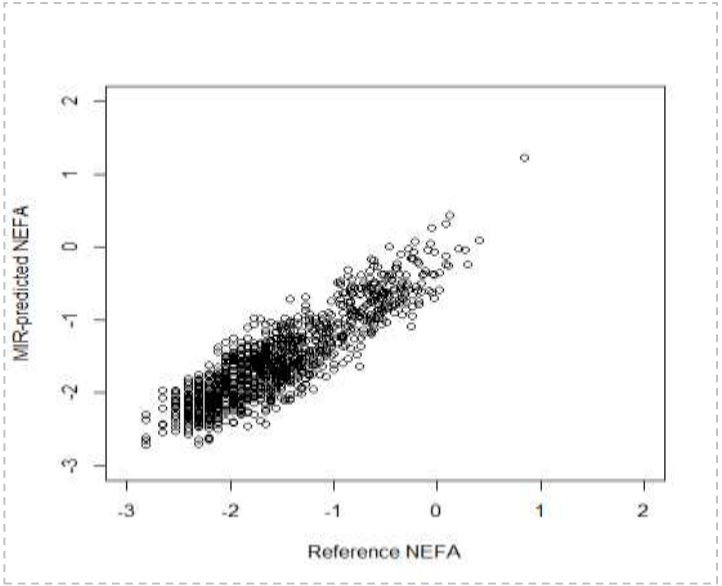
Scene 4: MIR-derived ketosis prediction tools

BHB



R = 0.87
SEC = 0.28
SDEP = 0.23
RPD = 1.8

NEFA



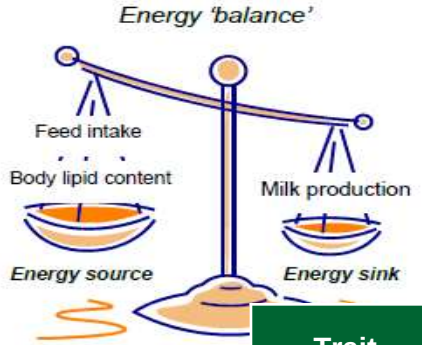
R = 0.88
SEC = 0.36
SDEP = 0.3
RPD = 1.9

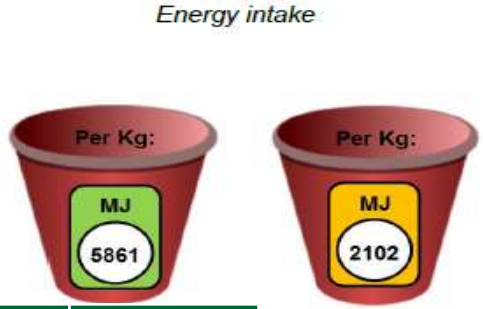
Scene 5: Tool application

- Records from Jan 2013 – April 2017
- All data standardised according to latest files (and available unstandardised)
- Over **13.7 million** animal testdates worth of spectral, **4490** herds
- Predictions
  - **13.6 million** fatty acid estimates (32)
  - **12.4 million** BHB and NEFA estimates
  - **12.5 million** energy balance, intake and content estimates

> 13000000000

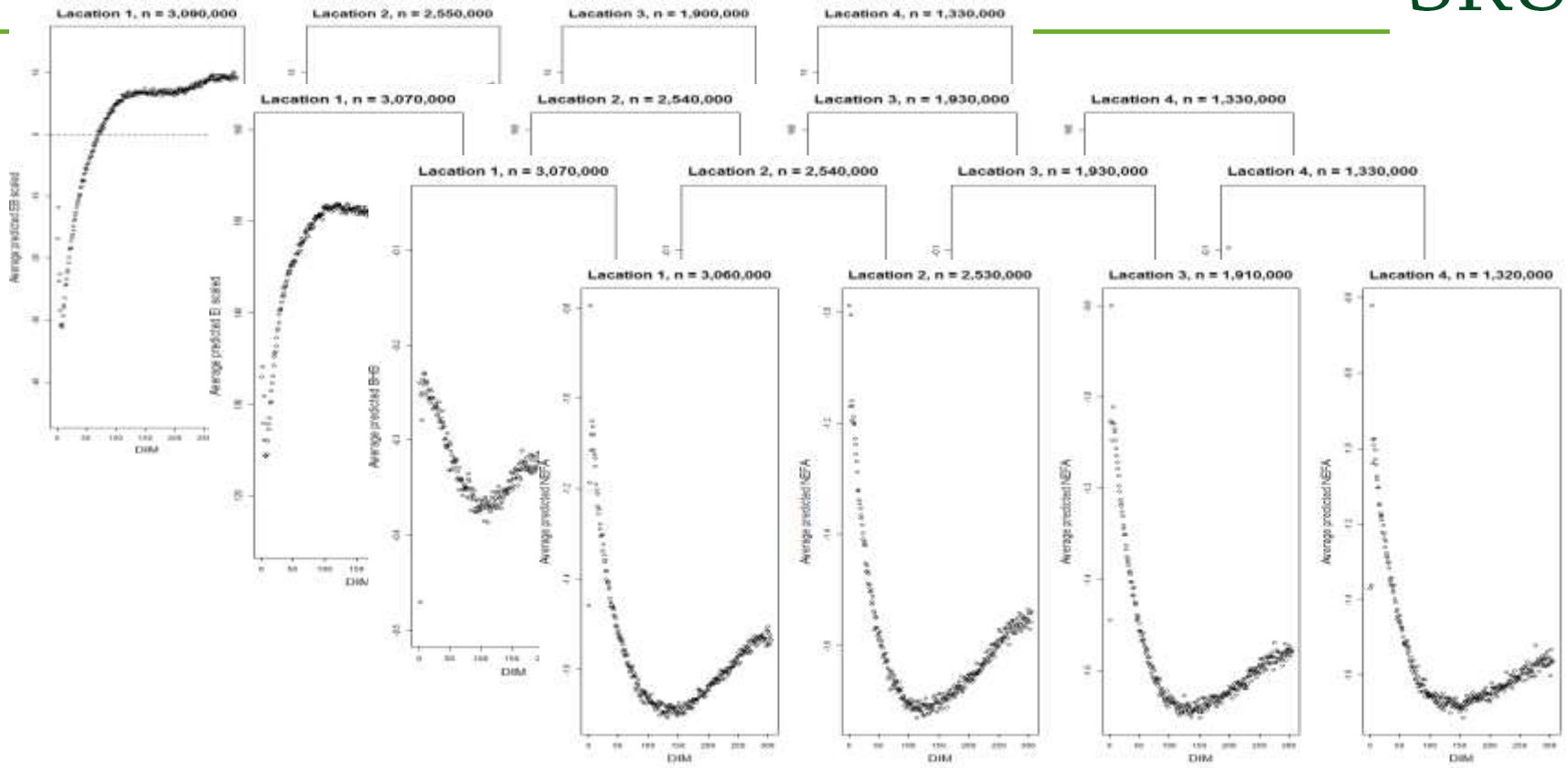
Scene 5: Tool application





Trait	N	σ_a^2	σ_{pe}^2	h^2	c^2	R
EB1_NR	1187081	105.55	31.09	0.07	0.02	0.10
EC_NR	1198706	93224.00	49349.00	0.21	0.11	0.32
EEI	1187423	178.15	7.26	0.10	<0.001	0.10

Scene 5: Tool application



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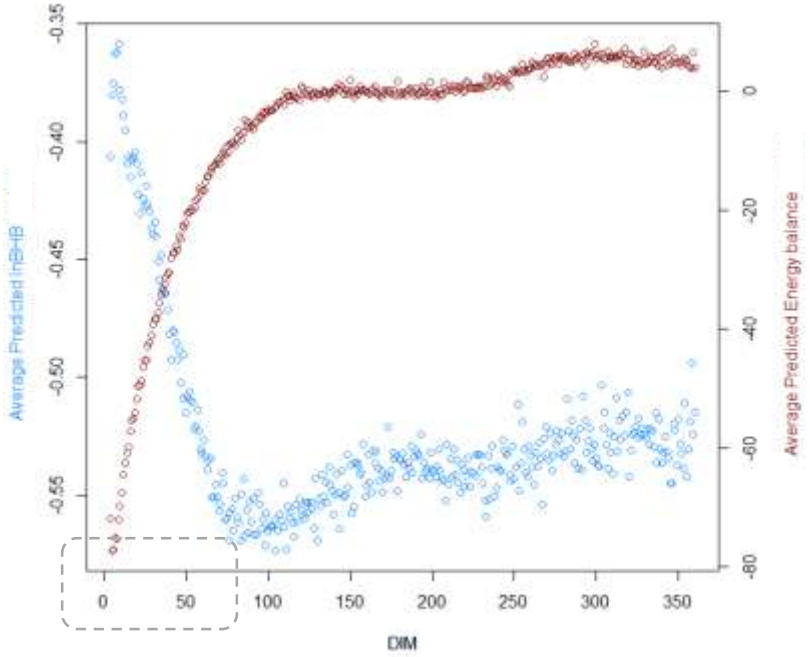
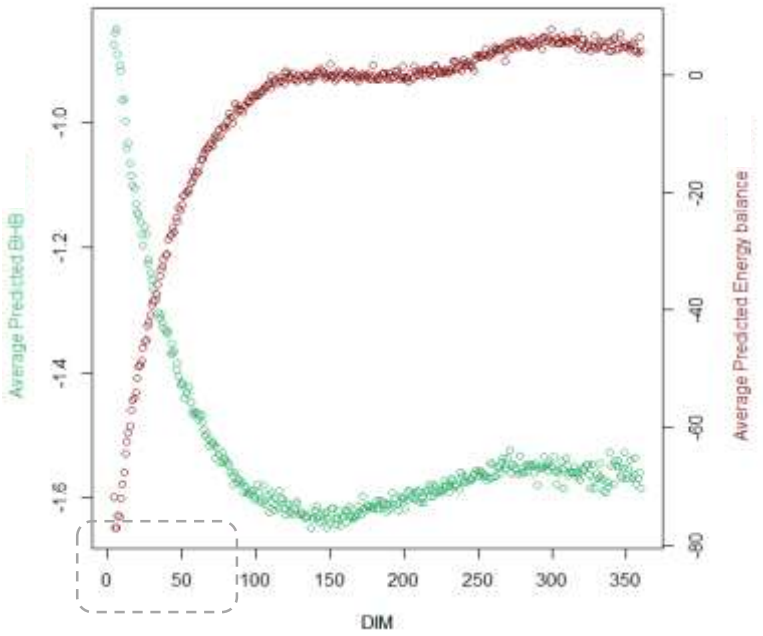
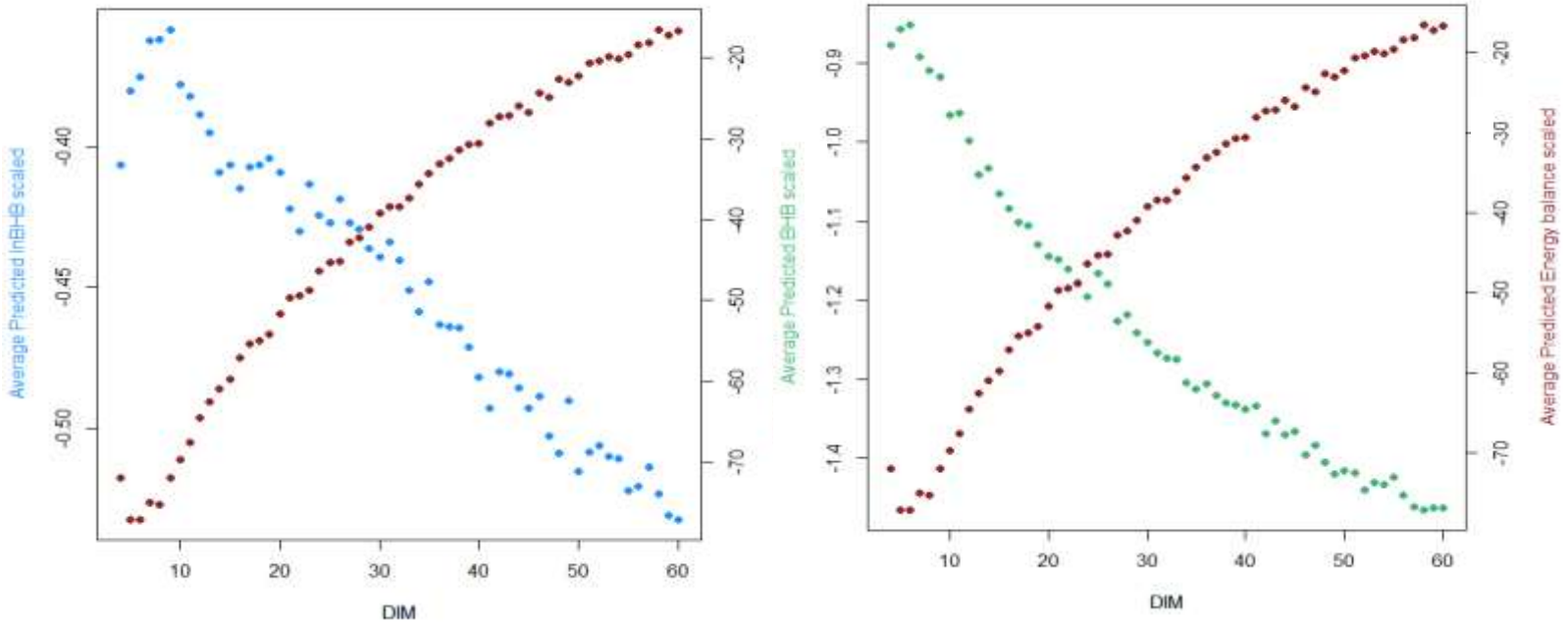




Predictions from 366 herds, >150,000 animals and almost 2 million animal testdates

Scene 5: Tool application



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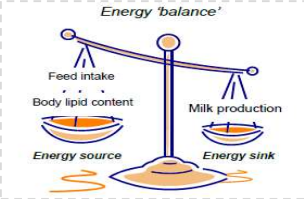
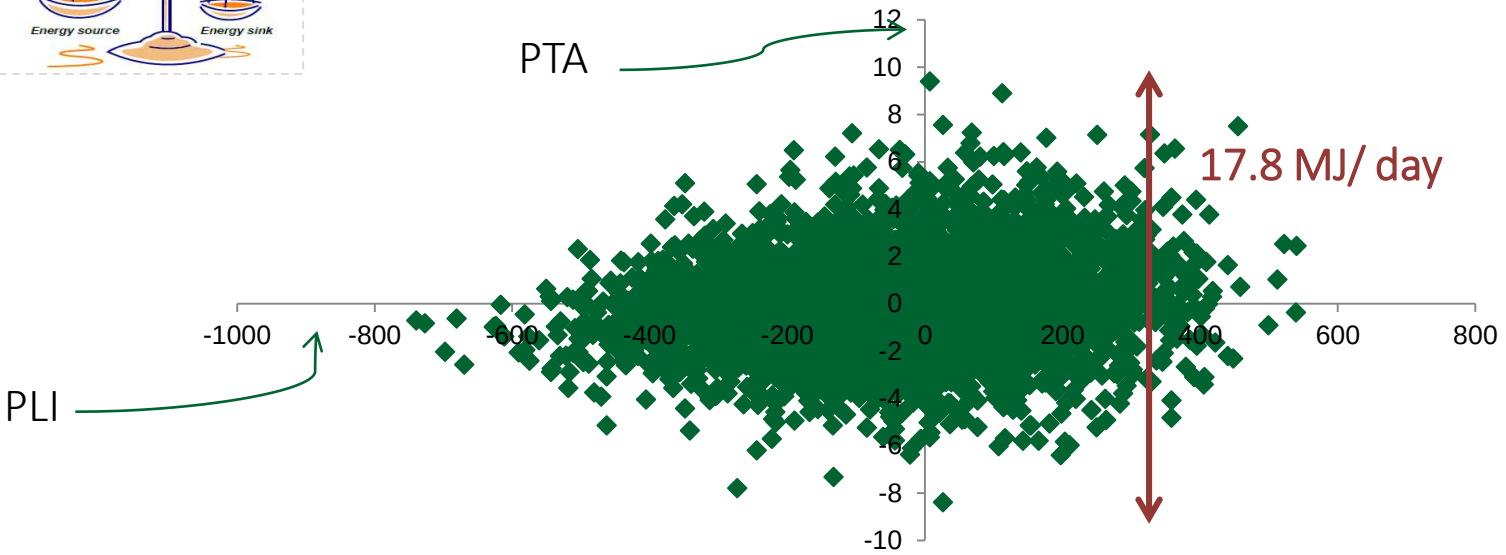
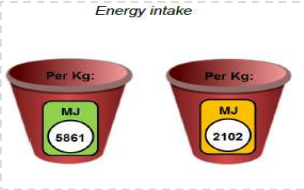


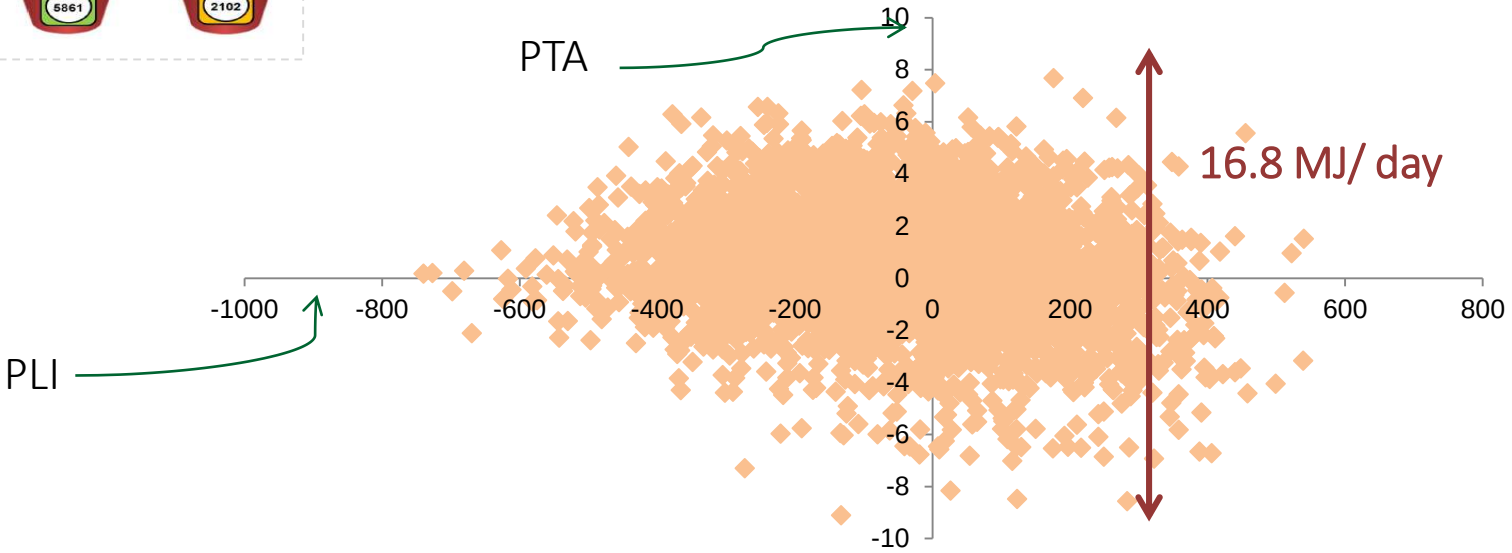
PLI vs. PTA for sires for energy balance



Scene 5: Tool application



PLS vs. PTA for sires for energy intake



- Demonstrated the ability to predict BHB and NEFA using MIR
- Could be used routinely as an early-indicator of potential health issues
- Energy balance predicted routinely from MIR at NMR; BHB and NEFA predictions due to accompany these

Scene 6: Conclusions and thanks

This work was funded by Innovate UK, BBSRC and the Scottish Government. This was completed with project partners National Milk Records, UK, who undertook the MIR analysis of the milk samples, and Marks and Spencer's. Procedures for managing spectral data came from collaboration with the Optimir project. Thanks to Tomasz Krzyzelewski and Umer Tahir for maintaining the national databases at SRUC.

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